Impact of global warming on large river sinuosity

Taking advantage of free satellite images handled with Google Earth Engine, this project aims to investigate the impact that global warming has on large rivers, looking at changes in their sinuosity and the development of riparian vegetation within their banks. As lateral migration of river channels allows for connecting the main river with its floodplains, eventually controlling sediment deposition and carbon stock outside of the main current, a reduction in river sinuosity might have negative feedback on the greenhouse-gas budgets of the Earth through the competing effects of silicate weathering and organic matter degradation under a warming climate.

Existing studies correlating changes in river sinuosity with climate are limited to cold regions, as those regions are more sensitive to climate change, and are experiencing a faster rate of warming. However, **a global dataset of changes in river sinuosity is still missing, and the present project will address this knowledge gap** by analysing large watercourses flowing at all latitudes.

Taking advantage of the recent development in acquiring and processing satellite information via Google Earth Engine, during the project the following research questions will be addressed, and the associated hypotheses tested:

Q1: What key metrics can be used to infer trends in river sinuosity and vegetation encroachment, using free satellite imagery?

H1: Landsat data can be used to investigate long-term trends of large rivers, and common metrics (e.g., Normalized Difference Vegetation Index-NDVI, Modified Normalized Difference Water Index-MNDWI) can give reliable estimates of variations at non-detailed scales.

Q2: What key metrics can be used to infer trends in global warming, with particular reference to riverine environments?

H2: Satellite-derived indexes are reliable in providing large-scale trends of climate variables such as air temperature, soil moisture and precipitation.

Q3: Does global warming affect river sinuosity at spatiotemporal scales observable via remote sensing at all latitudes? Is 40-year (Landsat data) a sufficiently long period to observe climate-driven changes in the fluvial platform?

H3: A hotter climate is contributing to reducing overland flow and seepage discharge along channel banks, and favoring the encroachment of vegetation on floodplains and banks, therefore stabilizing and strengthening river channels, with a reduction in sinuosity. The Landsat dataset is sufficiently long (40 years) to observe changes regardless of latitude.

Q4: What are the key drivers of the decrease in river sinuosity?

H4: Global warming is not only increasing the frequency of extreme events such as floods, which are paramount in increasing river sinuosity, but also reducing normal flow, therefore allowing vegetation to encroach banks, and reducing river sinuosity.

Q5: Is it possible to relate changes observed now in the Arctic regions to changes observed in the past at lower latitudes?

H5: The reduction in river sinuosity happens across all climate zones, but its timing and magnitude are different. However, given that changes are relatively fast, it is possible to track their history and compare different climatic areas.

The use of Google Earth Engine will allow for analysing a massive quantity of freely-available data in a semi-automatic way, and will guarantee the future uptake and transferability of the project outcomes. In this manner, researchers will be facilitated in analysing similar dynamics with different satellite data.

In summary, during the present project:

- unique datasets on river sinuosity, vegetation development and global warming metrics will be developed;
- open GEE algorithms and R codes will be created, allowing for reproducing the approach and expanding the research towards other directions;
- a baseline for investigating the influence of global warming on fluvial geomorphology will be developed.